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ABSTRACT

A computer simulation model for allocating facilities and physical space is presented as a means of optimally allocating available educational resources. The model allows the decisionmaker to change specific program allocations, system parameters, and other controllable variables in order to determine the effects, both cost and utility, of these changes on the total educational system. The discussion of the approach is broken into four topic areas: (1) model overview, providing a flowchart of the space simulation model and a narrative of the design; (2) input, generally describing the data base characteristics of the system; (3) processor, describing the technical considerations that have been designed in the system; and (4) output, discussing the final product characteristics of the systems. (Author/MLF)

ED 098704

A SYSTEMS APPROACH

FOR

ALLOCATING EDUCATIONAL SPACE

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INTRODUCTION

The purpose of this paper is to provide a systems approach in preliminary design of allocating educational space according to a school's planned program for its enrollees given the budget constraints. It is by no means the intent of this paper to cover the total spectrum of educational planning required prior to the allocating of physical space. However, factors that affect the final method of space allocation as well as an over-view of how these factors work as a system, an integrated and interralated whole, will be discussed.

The writer believes physical allocation of space to be one of the most important crises not only in education, but also in the entire world's economic and social system today. Reasons for this belief are:

1. Taxes, dues, and supplemental fees have risen each year - not only in America, but in many countries. The cry from the working man gets louder and louder each year wanting efficiency, justification, and downright elimination of many courses, and sometimes total programs.

2. Budgets have been used in the past by many educational systems in this manner: 'Let's set up our program, and then get the money." Education tends to complain about too little funds, and at the end of a school year, dump the left-over funds they have skimped from valuable areas, into anything-just to get the money spent so they can up the budget the next year.

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3. There is just so much space. Population continues to rise, while the amount of space available on the earth remains nearly constant. There will come a day when no more permanent building can occupy space, and we may live to see the day when money is not the criteria for land purchase, but a 'utility' or the worth of the project for which the land is desired is the criteria.

Therefore, working from a belief that these are factors which should be considered when planning for space allocation in education, the design presented herein works from a definition of space allocation to include not only existing space, land upon which new buildings can be erected, and addition to existing buildings. The design will also consider as a weighted factor available space that may not be owned by the school system which can be rented, leased, or bought and remodeled.

Figure 1 provides an over-view of the educational system. It shows what must be in the total management information system in order for the school administration to make the best decisions. The school board will need more of the information than the particular schools using the same system would need. However, the comprehensiveness of the information should make it possible for either to use it effectively. And, it could be set up in the same manner for the state - and national educational administration.

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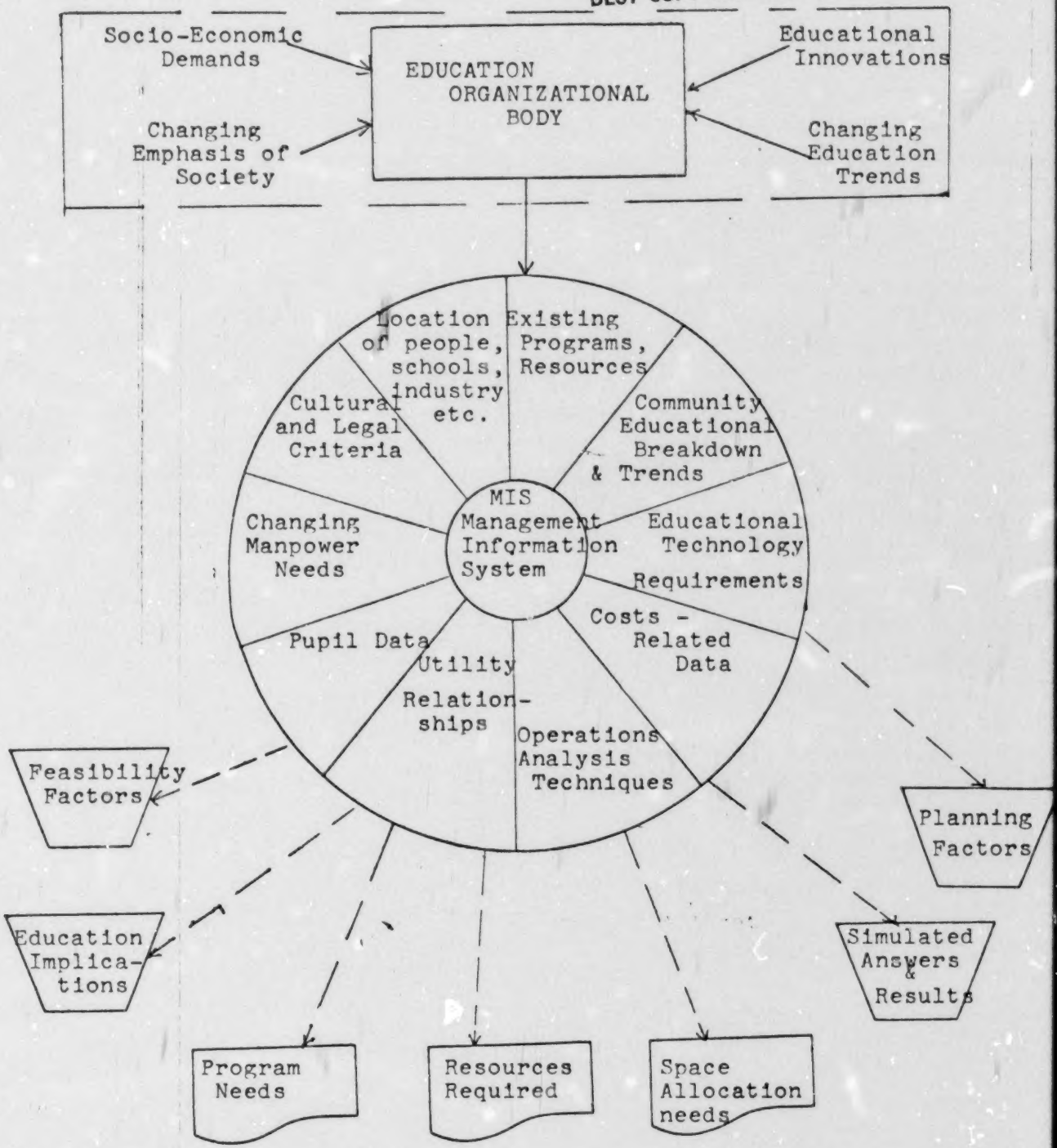

OVER-VIEW OF THE EDUCATIONAL SYSTEM

Figure 1

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From Figure 1, it can be seen that the information has a significant dependence on data from other systems within the environment. Schein states that an organization that adapts to its environment can be effective.[1] Since education is one of the most important organizations in society, it becomes even more important that it adapt to the changing needs within the environment since it feeds its output into other organizations - and more important, it (education) is what is molding the products of our society. Therefore, it is necessary for education to apply the adaptive-coping cycle that Schein uses in reference to organizations which is essentially the systems approach. That is, sense what is going on in the external environment as well as the changes around the nation in the internal environment of education, import the relevant information and put it into process for exporting better prepared students or products, and continue to monitor the change as well as continue to sense new changes in the environment.

To keep an accurate information system, then, the data must be kept in two categories. One, what the present educational system looks like, as well as the present external environment. And two, what the trends are in other educational systems and in society. Figure 2 gives an over-view of the Social-Economic System as the external environment and how it influences the Educational System: that is, if the educational system is to continue to be effective.

[1]Edgar Schein, Organizational Psychology, Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1966, pp.156-160.

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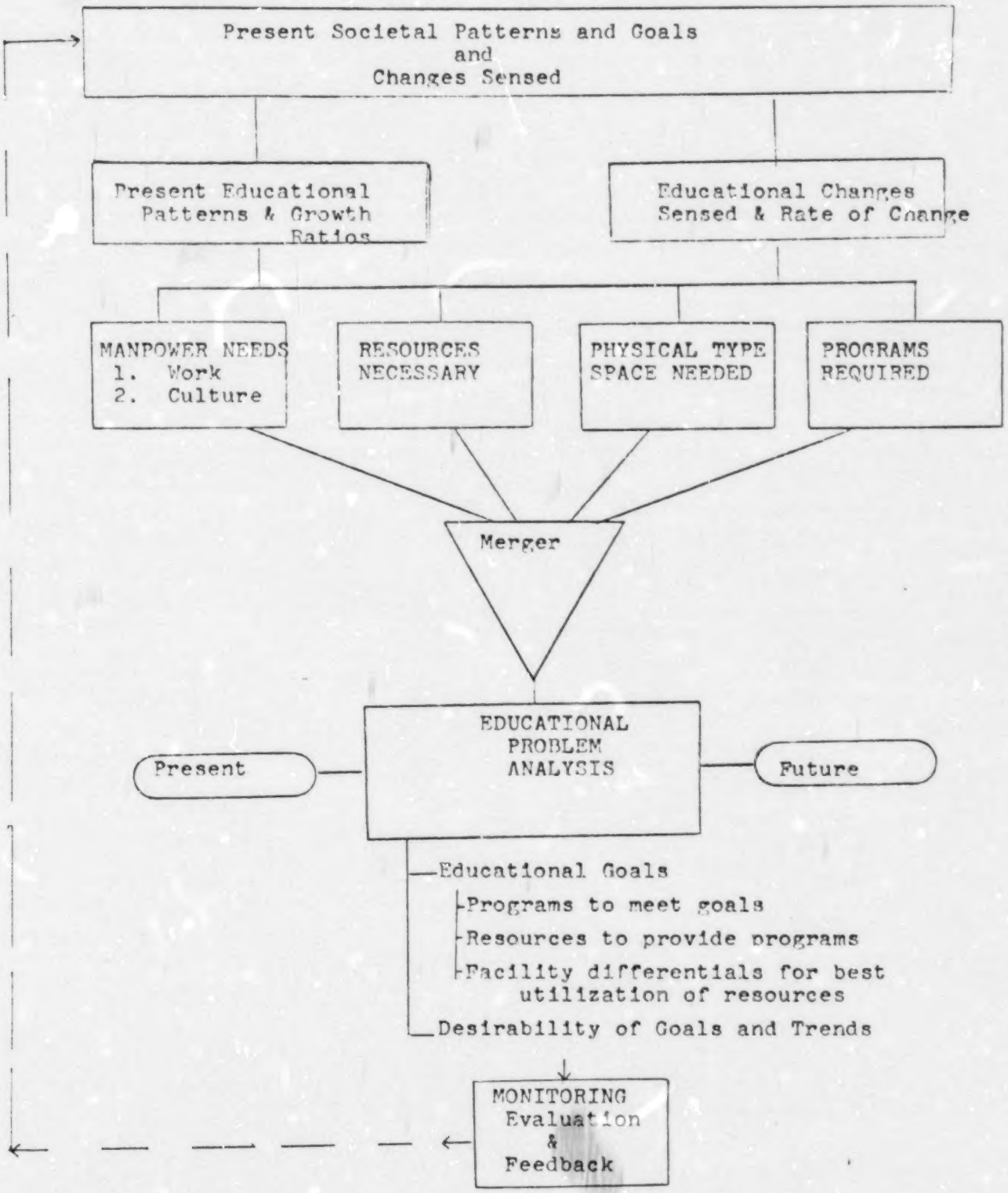
SOCIO-ECONOMIC SYSTEM AS IT INFLUENCES THE EDUCATION SYSTEM



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The Socio-Economic System presented in Figure 2 and the Educational System presented in Figure 1 provide enlightenment as to the complexity of the educational system and, thus, to the involvement required in the decision-making process. As stated by Banghart[2]:

> In most school systems the time has past when the superintendent could monitor all functions of the system by personal observation. The superintendent, therefore, needs access to modern techniques to monitor the system on a day-to-day basis in order to make make effective decisions about the school system.[2]

In most school systems of today, there is a separation of responsibility in such a manner that certain decisions are the responsibility of administrator(s) a whereas others are the responsibility of administrator(s) or departments b, c, and d. The superintendent cannot handle it all.

This paper will focus on that subsystem within the educational system that will be concerned with the allocation of space after the curriculum is given, projected enrollees have been given, and some type of budget constraints have been given. However, prior to the chapter that will deal specifically with physical space, a review of related literature will be presented. The intent in this review is to look into factors considered in the two figures of system over-views and see what has been done with them. And, also, to look specifically for related literature to how others may have approached facility allocation.

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[2]Frank W. Banghart. Educational Systems Analysis, London= The MacMillan Company, 1969,p.23.

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REVIEW OF RELATED LITERATURE

One of the considerations for placing the output of the educational system into effective positions in society is the supply-demand factor or manpower requirements. Since one of the principal hindrances to the geographical adjustment of labor supply to demand is ignorance of comparative employment prospects and job requirements, the most direct method of speeding the adjustment is by compiling and making available current information on these questions.[3] Supply-demand criterion should not be the sole factor to consider in the development of curriculum. However, it does need more emphasis in the school system. Kaufman and Brown note that "One of the basic principles underlying the Vocational Educationa Act of 1963 was that youth would be trained for occupations (supply) for which society has a need (demand)."[4]

Woodhall, reviewing the literature on educational planning, comes to the following conclusion:

> The interdependency of the educational system and the occupational structure of the labor force has been so frequently emphasized that many countries, both advanced and underdeveloped, have drawn up detailed estimates of future manpower requirements which are used to determine the rate of expansion of secondary or higher education.[5]

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[3]Edgar M. Hoover. The Location of Economic Activity, New York: McGraw-Hill Book Co.,Inc.,1948,p.268.

[4]Jacob J. Kaufman and Anne F. Brown, "Manpower Supply and Demand," Review of Educational Research,38:326(October1968).

[5]Maureen Woodhall, "The economics of Education," Review of Educational Research, 37: 391 (October 1967).

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The relationship of the manpower-requirements approach to socio-economic planning, especially seen as an illustration of how local vocational education programs can contribute to the economic development of a specific geographic region, is described in the (PVES) Pennsylvania Vocational Education Study.[6] Although this application was local, it does demonstrate how local planners as well as state planners might view the long term consequences of structuring their programs to meet emerging economic needs.

On the idea of equity as balanced against requirements for efficient production of students, or a form of cost/utility, Anderson says that the most 'realistic' is continued education so long as gains in learning per input of resources match some agreed upon norm. This may also be a definition of system efficienty. He goes on to say give priority to those groups or areas where given inputs will evoke the largest response in attendance and in demand for further schooling. Anderson suggest this is the most practical; it relies on ability to sacrifice earnings and/or leisure and requires demonstrated aspirations and performance.[7] Because this is a meritorious approach and favors the most developed groups in a society, and therefore offends many people, particularly those in lower social

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[6]Walter M. Arnold, Vocational, Technical and Continuing Education in Pennsylvania: A Systems Approach to State-Local Program Planning, Harrisburg, Pennsylvania: Pennsylvania Department of Education, 1969, pp. 203-259.

[7]C. A. Anderson, "Patterns and Variability in Distribution and Diffusion of Schooling," Education and Economic Development, Aldine, Chicago, 1965.

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structures. His second definition is to maximize the ratio of economic gains to educational costs, which is what many developing countries attempt to do, and is an approach which tends to operate relatively well.[8]

Most school districts in our country do not employ any computer-assisted budget preparation, resource allocation or planning systems. Of those schools which do utilize some computer-assisted process, most are operated at a relatively low level of planning sophistication. The following is an example of the better systems of this type: This system is a computerized approach used to prepare the annual budget of the Charter Oak Unified School District of Covina, California. It is called the S-Plan (School Organization Budget Planning System) and permits an administrator to try a variety of budget alternatives in a single planning session. The S-Plan was first tested simultaneously with the traditional manual procedures. The totals produced by the computer-based system as compared to the manual procedures had a maximum of one and one-half per cent difference. However, the manual procedure required seven man days to prepare, compared with the S-Plan time of two hours using a computer and tele-typewriter.[9]

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[8] Ibid.

[9] Lake W. Krebs and Frank A. Yett, "S-PLAN: Computerized Data System Helped Schoolmen Plan Budgets," Nations Schools, Vol. LXXX, (October, 1967), p. 67.

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Reisman and Taft outline an approach to educational resource allocation which utilized PPBS and utility/cost analysis. Their methodology consists of defining some composite utility function for learning effectiveness and, then, allocating resources in order that the utility function is maximized and kept monotonically increasing at as high a rate as is possible through time. By assuming the total or composite utility of a program in terms of learning effectiveness as a function of the quality and mix of the various competing alternatives: the model purports to answer such questions as:

1. How much utility is contributed by each of the programs, departments and/or projects in a given institution to the total utility of this institution assuming the existing mix of resource allocations?

2. How will the utility of a given institution change under a different mix of resources?

3. How does the utility of one institution, at a given time and a given resource mix, compare with the utility of another institution of a similar class with similar goals and objectives.[10]

Although this model deals basically with resources such as teachers, materials, desks, etc.; some of the criteria influence the resource allocation will also influence space allocation.

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[10]Arnold Reisman and Martin I. Taft, "A Systems Approach to the Evaluation and Budgeting of Educational Programs," Socio-Economic Planning Science, Volume 3, (1969), pp. 245-248.

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A simulation system model has been developed to aid in resource allocation within the Faculty of Arts and Science at the University of Toronto. In essence the model is a simulation exercise of university operations over a time period of specified length. Four divisions, enrollment formulation, resource loading, space requirements, and budgetary calculations, are moved through sequentially and the general output consists of calculations regarding the resource requirements of staff, space, materials and money.[11]

Since the purpose of this paper is to present a preliminary design to space allocation it is necessary to talk about cost/utility analysis. However, detail will not be furnished, but rather an abbreviated narrative since utility will be an input furnished to the system. The model will assume the development of a utility theory applicable to the relative ranking of educational programs. The purpose of a cost/utility analysis is to quantify and measure the costs and benefits of each alternative proposed. There are a number of costs to be considered, and it is important that the same costs are being considered for each alternative. If there is a time-frame separation between alternatives, the cost must be distributed to a common time-span to permit uniform analysis and comparison.

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[11]Richard W. Judy and Jack B. Levine, A New Tool For Administrators--Educational Efficiency Through Simulation Analysis, Canada: Univ.of Toronto Press,1965,pp.vii-viii.

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Utility should be measured in terms of the objective criteria established. Systems analysis represents an approach to solving any problem of choice under uncertainty and every systems analysis involves at some stage a comparison of alternative courses of action in terms of their costs and their effectiveness in attaining a specified objective.[12] Therefore, a systems approach using cost/utility analysis criteria should lead to a better technique for decision-making in space allocation.

E. S. Quade outlines the process of analysis as is applicable to the problem at hand.

1. Discover what the objectives are (or should be) and how to measure the extent to which these objectives are attained by various choices.

2. Determine the alternatives by which these objectives can be attained.

3. Determine the true costs of the alternatives. True costs includes the true measure in terms of the opportunities they preclude.

4. Develop a model which represents the real world--this representation may range from a set of mathematical equations or a computer program to a strictly verbal description of the situation.

5. Provide a criterion to rank the alternatives in order of desirability (determined by comparing cost and effectiveness.)

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[12] E. S. Quade, "Systems Analysis Techniques for Planning-Programming-Budgeting," Document P-3322, Santa Monica, California: The RAND Corporation, March, 1966.

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The advantages of these techniques lie in the attempt to look at the entire problem systematically with emphasis,on explicitness, quantification and the recognition of uncertainty.[13]

The present emphasis and attention given to more quantitative techniques of resource allocation (i.e. programming-planning-budgeting systems (PPBS) and systems analysis) results from explicit recognition of certain deficiences in decision-making processes regarding allocation of public funds. The objectives of public programs are not defined in operational, i.e., quantifiably measurable, terms; hence, program accomplishment -or lack thereof - is frequently not considered. Budget analysis is generally centered on expansions and new services; further, the operating and capital budgets are seldom fully integrated; and there are many other recognized deficiencies.[14] It seems that the actual process of school budget preparation consists of extending last year's budget into the next year, modifying it to recognize just grants, tax, and salary increases. This method neither produces a careful weighing of educational priorities nor assures maximum yield from the volume of educational resources used by the district. Hopefully, the space model provided herein allows for a better approach.

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[13] Ibid.

[14] Charles S. Benson, The Economics of Public Education, 2nd edition, Boston: Houghton Mifflin Company, 1968, pp.251-252.

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In a society where there is a changing economic base, the role of and the needs of the family is in a const
constant state of flux. Unless these needs are met and the changing roles are considered in relationship with the overall economy, then the changes that are made in the economy will have little or no permanent effect. With an increasing population due to increased birth rate, lowered infant mortality, extended life expectancy, and many other demographic factors, the role of the family participants will change. To meet these changing needs, information must be disseminated through the educational process. It does not make sense to set up an organization without knowing what teaching is going to be taught at what place with what to whom.[15] That is, what programs are going to be offered through what technical capabilities in resources and facilities to which group of persons. Hence, the effectiveness of an individual's education is a function not only of what he has acquired in the process, but also the educational level of the community as a whole.[16] To say this in another way, if the trends of society are taken into the educational information system, then more effective education can be given to the student products for increasing the community level of economic effectiveness - and also society as a whole.

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[15]Talcott Parsons, "Some Ingredients of a General Theory of Formal Organizations," Administrative Theory in Education, edited by Andrew Halpin, 1958.

[16]Ibid.

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Trends in the internal environment of the education system must also be considered. Educational technology should be employed where it contributes to more efficient and effective education. The major form of expansion in educational technology has been in the planning genre where planners stress technology in education as one of the central elements in plans for the future of education. Coombs offers an 'ideal' concept of educational planning which he suggests should be a goal for planning, but rarely is reached:

> The ideal concept envisages educational planning, first, as embracing in orderly fashion all the levels and forms of educational activity, both formal and informal, within the country, and, second, as being fully integrated with the country's economic and social development plan, so that education may serve most efficiently and effectively the needs of both the nation and the individual.[17]

Coombs goes on to say that educational planning should focus directly on planning for educational change rather than simple planning to cope with educational growth - and this change orientation should operate from the standpoint of inventing, testing, modifying and implementing new learning systems and subsystems.[18]

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[17] P. H. Coombs, "Some Reflections on Educational Planning in Latin America, Problems and Strategies of Educational Planning, Paris: UNESCO, IIEP, 1965, p.4.

[18] P. H. Coombs, The World Educational Crisis: A Systems Analysis, New York: Oxford University Press, 1968, p.33.

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Educational technology has received close scruting in recent years because it means such different things to everyone. A basic agreement of its meaning has formed over the past few years, however, and Gagne states its meaning as follows:

> Educational technology ... can be understood as meaning the development of a set of systematic techniques, and accompanying practical knowledge for designing, testing, and operating schools as educational systems.[19]

Much of the impact of technology is lost because of the apparent inflexibility of the educational system and because the products of technology are usually employed in a piece-meal fashion, according to Morgan. He goes on to say that many critical variables in the educational system which affect student learning must be considered, since these variables do not operate in isolation from one another; these include the instructional objectives, the role of teachers and administrators, the physical environment or the physical space in which the learning is to take place, motivation and background of the students, the instructional processes and more.[20] Other variables that must be considered in affecting student learning, which lie in the larger societal system include governmental-political policies, commercial-economic-industrial patterns, philosophical-religious beliefs, cultural norms, as well as the traditional patterns.

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[19] R. M. Gagne, "Educational Technology as Technique," Educational Technology, (November 15, 1968), p.6.

[20] Robert M. Morgan, "A Review of Developments in Instructional Technology," Florida Journal of Educational Research (January, 1969), p107-103.

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The overall plan for education should identify all the
the activities that must be completed prior to the the operational implementation of a curriculum. The specific tasks to be done range from the preparation of inservice training programs for staff to carry out the educational goals to the analysis of design requirements for facilities or necessary space.[21]

The model being presented in this paper is, in a way, a different approach to the concept of facilities for education. It works beyond the normal understanding of facilities to include areas of space not tied directly to the purse strings and facility control of the school system, but also to that space whereever it may be that allows for individual differences, educational innovation, program differences-and perhaps lead to a decrease in the heavy cost impacts of dropouts, repeators, building requirements and restrictions, and restrictive education of the child. By allocating space according the the educational technology being used for a program teaching; individual differences in abilities, aptitudes, rates and ways of learning; optimizing appropriate combinations and interconnections of various resources;[22] and emphasizing the non-formal education, recognizing and capitalizing on the fact that most learning is outside of the formal system, it just might lead to modernization of education and mean

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[21] Ibid., p. 108.

[22] Op.Cit., Coombs, 1968, p169-177.

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significant reallocation of resources to 'non-formal' physical space.

Much of the educational space will continue to be fixed space, however, and innovations for making the space as 'learning oriented' as possible must be considered for the best turn-over and output of the educational product - the student. Some spaces have been created according to a collection of planning, programming, and design guidance for multi-media classrooms - a work sponsored by the Educational Facilities Laboratories. Follow-up for evaluating the effectiveness of these multi-media classrooms was done recently and the reporters came to the conclusions that 1)multi-media space can be the most valuable space on campus, or it can be a white elephant; 2) both educator and architect must recognize the importance of the teaching-learning concept; and that putting it into practice will take a good deal of time and energy; and 3) that greater emphasis must be placed on the instructor as a user of these rooms.[23]

More research is still be be done for validation of factors taken to be influential in the allocation of space, other space location models that may be working effectively outside of the educational system, and factors which are relevant - but not presently taken into the model - which other designs may have found out about through monitoring of their systems.

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[23] David S. Haviland and William L. Millard, Multi-Media Classrooms: Part I: A Look at Some College Facilities

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PRELIMINARY DESIGN OF A PHYSICAL SPACE ALLOCATION MODEL

The primary function of management is to develop the optimal allocation of available resources; the assumption underlying this statement being that there is a definite limitation of the resources available.[24] By combining educational planning objectives with pertinent information regarding population projections, historical program trends, and alternative program costs and utilities (in a manner as viewed in Figures 1 and 2), a more effective allocation of resources is possible. As a means of allocating these resources, a planner may utilize a projective computer allocation model which illustrates alternative courses of allocation by simulating the educational system in order to perform utility/cost analysis.

This type of computer simulation model would allow the decision maker to change specific program allocations, system parameters, and other controllable variables in order to determine the effects (both cost and utility) of these changes upon the total educational system. An iterative process of examining different alternatives assists the administrator to reach a more optimal allocation based upon the principle of maximization of utility or minimization of cost. The goal of building a simulation model for allocating facilities or the physical space for education is not to recreate reality, but to abstract

[24] Bangham, op. cit., p. 108.

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the study important aspects and relationships from the real system and express them in a format which is suitable for analysis. Then, by operating upon the model, the user is able, hopefully, to draw conclusions that are valid for the real system being studied.

Thus, an advantage of simulation models through the use of high-speed computers is that simulation may incorporate a degree of detail which would leave mathematical systems intractable. The ability of simulation models to reflect the detail of organizations makes them powerful tools of analysis. The decision maker is able to test alternatives on the model before actual implementation. Furthermore, more accurate and better substantiated statements of financial needs may be prepared with a simulation model.

A final advantage realized in developing a simulation model is that its integrated systems view of operations brings a new perspective to educational administration.[25]

As the cost of computers is reduced, it becomes more feasible for many of the larger school districts to purchase or lease their own computer hardward and set up a dedicated computer installation. And, as stated by Carl E. Wilsey, smaller school systems can enjoy these same benefits by contracting for data processing services or by joining together with other school systems to operate a computer

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[25]Judy and Levine, op. cit.

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center that can serve all the students. He feels that almost every district can make us of data processing through one or a combination of these approaches.[26] Through the use of computers in education the time-lag between an event occurring and the decision on that event can be reduced. Also more accuracy through less data handling by different divisions of education can occur.

The scarcity of resources which are available to educational systems mandates that methods of resource allocation be improved. These decisions in re-allocating scarce resources and facilities can only be reached if several alternative avenues of action are available along with information regarding how the system will respond over a period of time if each alternative is implemented.[27] Thus, a simulation model which accurately represents the system can be used to detect future possible fluctuations of the system and monitor the existing system for further evaluation and planning.

Since the greatest benefits are hoped for at a minimum of cost, the criteria needs to be easily changed when needed and also made available to the administration on request. Forrthis reason the approach taken in the preliminary design of space allocation encourages man-machine interaction to allow the administrator to make modifications as often as

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[26]Carl E. Wilsey, "Are You Ready for Your Own Data Processing Center?", American School and Univ,(Oct,1968),p.32.

[27]Frank W. Banghart, et.al.,"Simulation of Space Needs and Associated Costs," Document No. 731702,Educational Systems and Planning Center, The Florida State University,1970,pp.2-3.

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he wants. He would also be able to see the results of his changes immediately and be able to iterate the process until a resource and facility allocation report that would be satisfactory to all concerned could be obtained. This keeps evaluation and control in the designated hands of administrative management.

The discussion of the approach taken in the preliminary design of physical space allocation will be broken into four topic areas. One, model overview, which provides a flowchart of the space simulation model and related narrative of the design. Two, input, which generally describes the data base characteristics of the system. Three, the processor, which describes the technical considerations which have been designed in the system. And four, the output, which discusses the final product characteristics of the system.

Model Overview

Figure 3 illustrates the general flow of the on-line space allocation model. The flowchart demonstrates the dependence of the model on inputs from the over-all educational system and the type of output the administration can expect.

Figure 4 provides a more detailed view of how the system will work in logical sequence and the information flow activity prior to final outputs.

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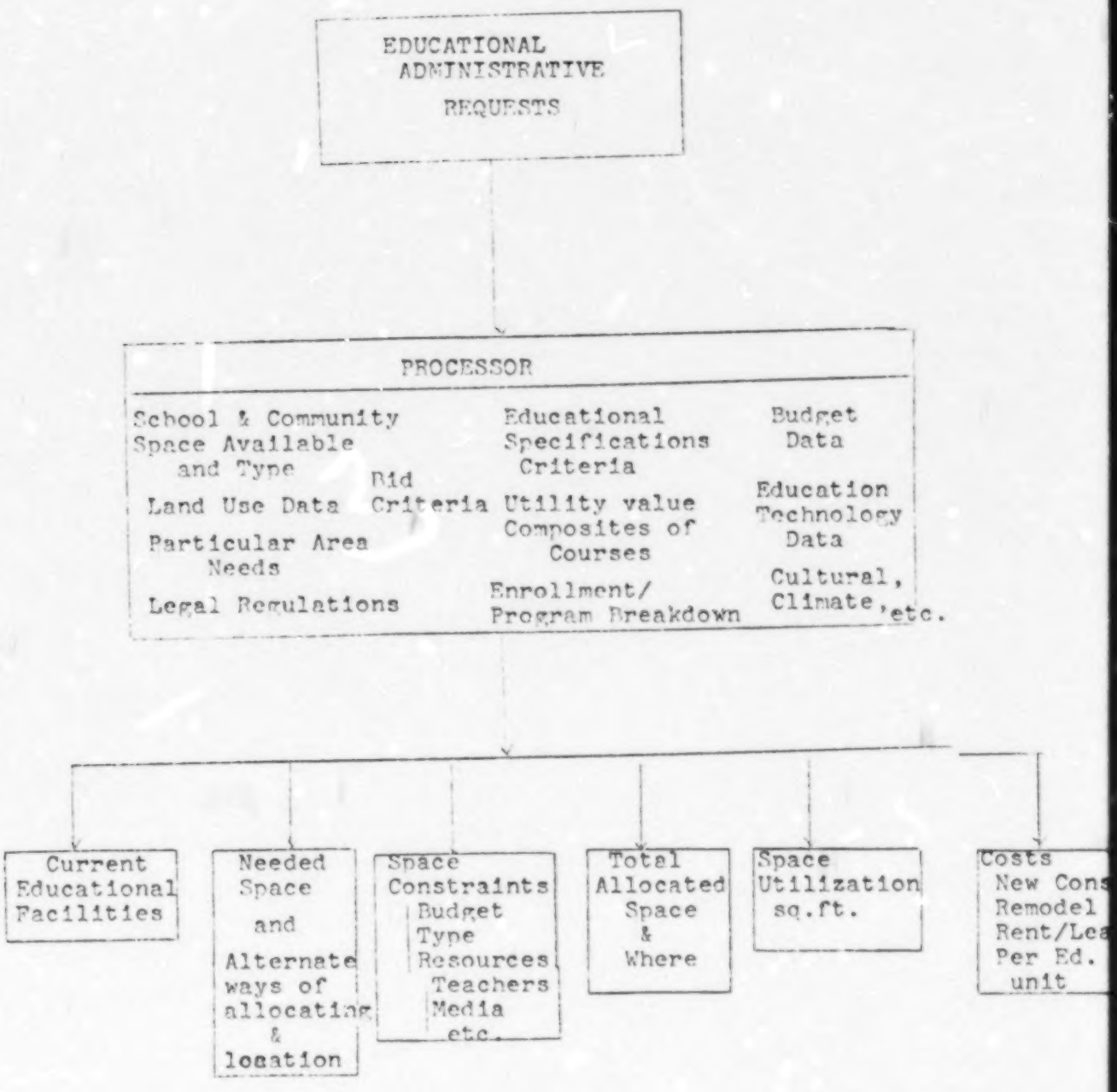
GENERAL FLOWCHART OF THE SPACE ALLOCATION MODEL


EDUCATIONAL ADMINISTRATIVE REQUESTS
PROCESSOR
School & Community Space Available and Type
Land Use Data
Particular Area Needs
Legal Regulations
Bid Criteria
Educational Specifications Criteria
Utility value Composites of Courses
Enrollment/ Program Breakdown
Budget Data
Education Technology Data
Cultural, Climate, etc.
Current Educational Facilities
Needed Space and Alternate ways of allocating & location
Space Constraints Budget Type Resources Teachers Media etc.
Total Allocated Space & Where
Space Utilization sq.ft.
Costs New Cons Remodel Rent/Lea Per Ed. unit

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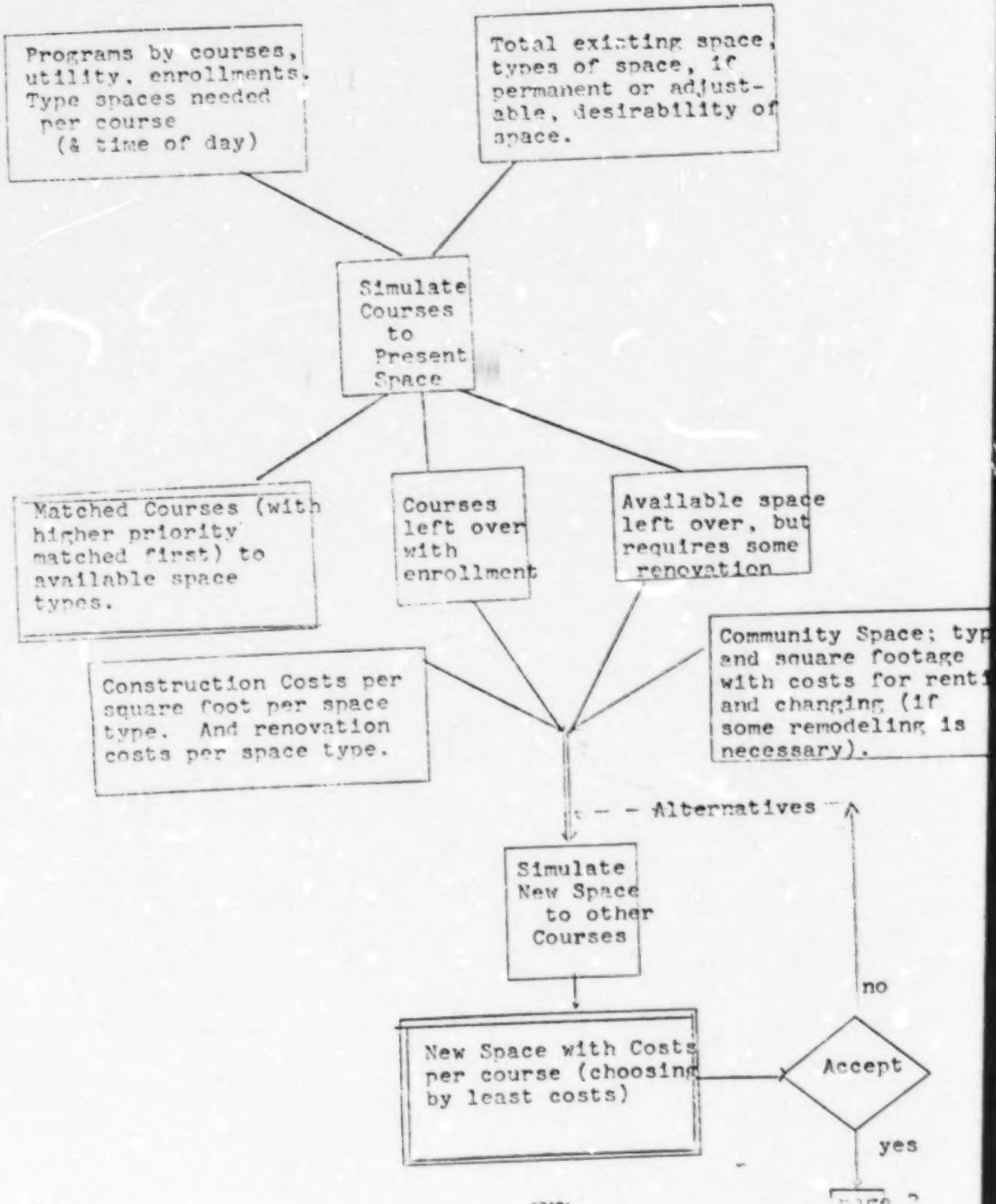
DETAILED FLOWCHART OF LOGICAL SEQUENCE OF THE SPACE ALLOCATION MODEL


Programs by courses, utility, enrollments. Type spaces needed per course (& time of day)
Total existing space, types of space, if permanent or adjustable, desirability of space.
Simulate Courses to Present Space
Matched Courses (with higher priority matched first) to available space types.
Courses left over with enrollment
Available space left over, but requires some renovation
Community Space; typ and square footage with costs for renti and changing (if some remodeling is necessary).
Construction Costs per square foot per space type. And renovation costs per space type.
Alternatives
Simulate New Space to other Courses
New Space with Costs per course (choosing by least costs)
Accept
no
yes

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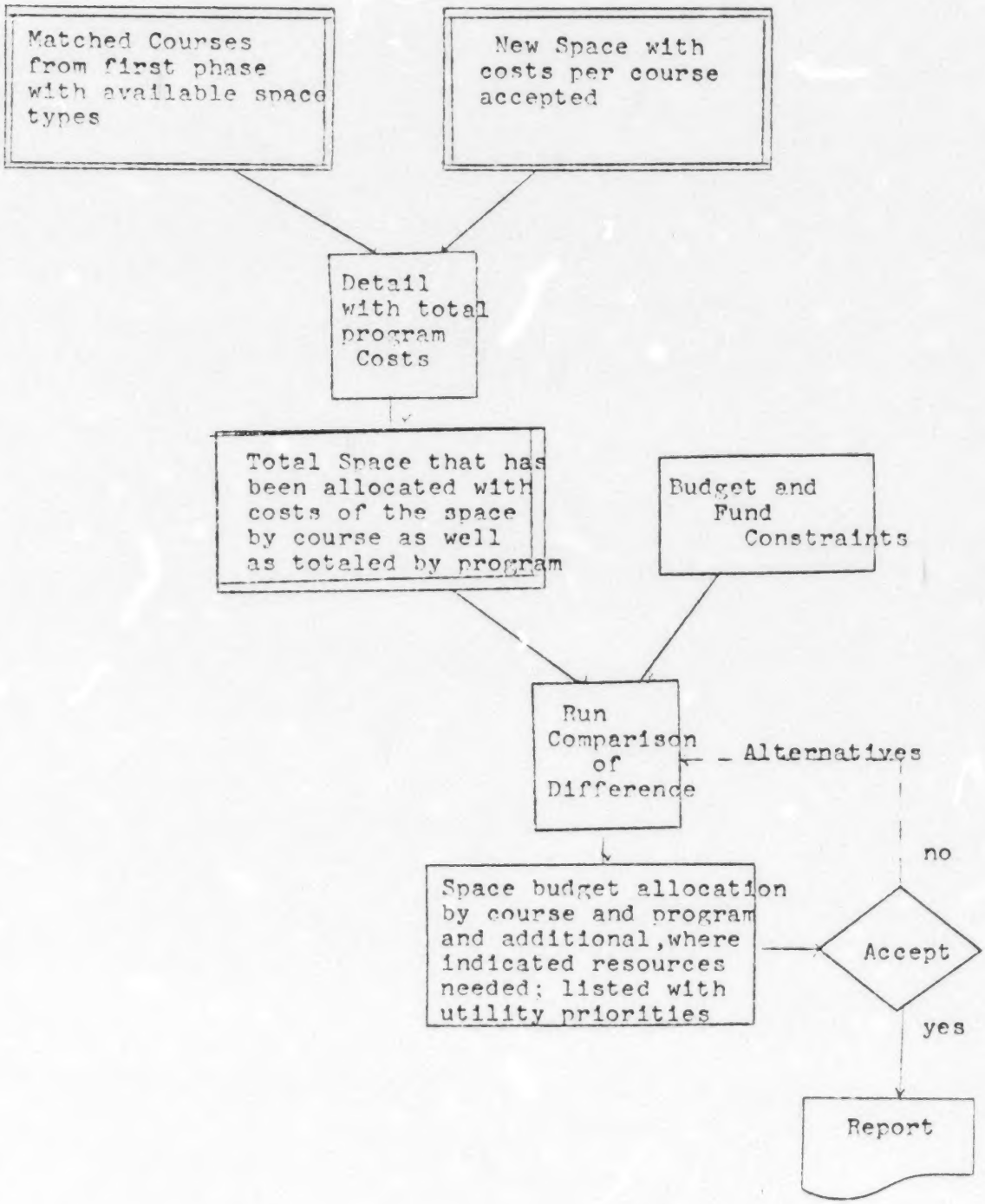
DETAILED FLOWCHART continued:


Matched Courses from first phase with available space types
New Space with costs per course accepted
Detail with total program Costs
Total Space that has been allocated with costs of the space by course as well as totaled by program
Budget and Fund Constraints
Run Comparison of Difference
Alternatives
Space budget allocation by course and program and additional, where indicated resources needed; listed with utility priorities
Accept
no
yes
Report

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Inputs

The following inputs are included in the data base for the Space Allocation Model.

Facility File:

Facility data are broken into present or existing physical space available in the school system, space available throughout the community, school space needing renovation, and sites available for new construction. The inventory of existing space will include the space type (i.e., laboratory space, regular classroom space, library space, or just what type of space is available), square footage per space type, and the number of student modules within a space type. A student module is the amount of space environment required per student in one particular activity. Activity refers to a particular course in a given time period such as algebra, math I, geometry, etc. within the total program of mathematics. The community space, the renovation space, and the new construction space will include the same data elements as existing space. It will also include, however, the cost associated with renting, renovating, or constructing new space and the desirability (or utility value) associated with using that facility.

Space is where you find it, and more and more communities, large and small, are looking to non-educational buildings for school-house use.[28] By utilizing found space, a school

[28]Rowlett Caudill Scott, Space Is Where You Find It, The Research Council of the Great Cities Program for School Improvement under a grant from Educational Facilities Laboratories, Inc., 1968.

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system can anticipate important savings in time and cost or through the renovation of existing but undesirable space. Building a new facility may be the worst of all possible decisions; especially with the fast pace change in making today. Many of the buildings owned by education today are obsolete or left vacant due to consolidation of schools.

Educational Programs File:

This file consists of data related to all of the educational programs to be included within the school system. This information includes the following data for each course within each program:

a. utility measure: as a composite figure of judgment through a comparison and ordering of courses through a ranking of opinion.

b. the probable number of enrollees

c. the desired space type for the best teaching to take place; if there is no 'best' type, then list alternatives.

d. the square feet needed for each student

e. the number of time modules that each course will meet per day, week, and year.

f. a rating, if the course considers individual learning differences and requires space allocated accordingly. (this would require either some detail on students within this type of course, or composite figures by category, for allocating 1 type space per course.)

System Parameters:

1. Population projections for a school system may be entered requiring the model to determine the number of students expected by program.

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2. Some future projection can be done depending on the number of years requested in the parameter.

3. The modules available per day and per week for which courses within a program can be scheduled will affect the ~~resources~~space required.

4. The budget for the total school curriculum is used for establishing an initial figure to be allowed per program for facilities expenditures.

5. If new construction is a space to be allowed in the allocation, then the dollar amount for construction costs must be entered and a yearly prorated rate.

6. If renovatable space is to be used, then the dollar cost for renovation should be entered.

7. Student-teacher ratios and teach load are necessary data elements in allocating facilities and teaching resourcesspace.

The Processor

The inputs described previously will feed into the ~~resource~~ allocation model. The model will then act upon the input data to obtain an initial budget for each program.

The algorithm for obtaining each initial program budget is based upon the criterion of utility/cost analysis. The mathematics used in the allocation algorithm for determing each initial program budget for physical space are:

$$PB_i = U_{p_i} \text{ times } \frac{TB}{\sum_{i=1}^{n} U_{p_i}}$$

where PB_i is the initial budget for program i, TB is the total budget to be allocated, and U_p is the utility of

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program i. Each educational program now enters an algorithm that assigns resourcesspace and the respective costs to each course according to its utility value. When the alloted budget for the course (determined as was the program budget above) is fulfilled, that particular course allocation is ended, and additional resourcesspace needed or unused course budget are recorded for later action.

Therefore, the constraints at this point in the allocation model are the budget limitations and the original utility assignments.

At the completion of the initial resource allocation, output is available to the administration of the school system. The administration is then able to interact through on-line activity. He can change the budget constraints, vary the resources per course or per program, or change the utility until a resource facility space has been obtained that provides what the administration wants.

A report is then prepared, and it compares the space allocation with the original utility assignments to assist accountability and future planning through seeing the impact of social and political factors supplied by the administration.

The facility allocation algorithm will attach a facility to a course according to the type of space needed, the capacity of the facility, and according to which space - new, found, or renovated - has the minimum dollar costs per year.

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Outputs

There are two types of outputs produced by the Space Allocation Model (Figure 3). These are as follow:

1. The on-line retrieval output produced at the terminal of the administration and used primarily for guiding the allocation iterations according to its wants, and for miscellaneous inquiry into the system.

2. Various batch reports produced at the high-speed printer are distributed to interested parties (i.e., school board, administrators, teachers, outside interest groups, etc.) to facilitate and encourage accountability in terms of space allocation. Other information is distributed to various responsibility centers to serve as their process activators.

The On-Line Retrieval Output:

The on-line displays with a brief explanation are:

1. Intermediate Space by Program Courses: Information regarding facilities (type and cost) allocated to the various courses within a program and the necessary utility/cost data to guide the administration to a more effective allocation.

2. Final Resource Allocation by Program Courses: Same as above in format; however, it is available for retrieval at any time.

3. Miscellaneous Information Requests: General nature requests regarding data such as space and resource utilization, number of student modules required of a particular course and the cost of various space types.

The Batch-Report Output:

Those reports which require considerable printing should be produced on the data center on a high-speed

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printer. A listing of these batch reports are:

1. Course Student Module Cost by Program: Relates student module cost by course by type of space.
2. Course Facility Requirements by Program: A report with the various types and amounts of space needed.
3. Course Utility/Cost Data by Program: A listing of all the courses and the corresponding utility/cost ratio in ascending order (accountability oriented.).
4. Detailed Course Space Allocation: This is a comprehensive report containing a list of allspaceneeds per course, how many students within that space for the activity, and the space utilization.

More reports could be obtained from the space simulation model if the administration desired the output. The basic purpose of the information is for the administration to have up-to-date criteria upon which to make decisions, monitor the out-come of the decisions made, feed the results back into the data base for updating of criteria, analyze whether or not the information is adequate.

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CONCLUSION

Physical space allocation for educational programs is a necessary and important function in the educational system. It takes up a major portion of the school budget and has something to do with the learning that takes place in the given space. Therefore, a systematic procedure for allocating funds needs to be developed and consideration needs to be given to the development of the 'best' space for the individual learning in that space. Good education is not cheap; however, by working toward increased quality of output while holding cost relatively constant, at least the effort may produce some positive innovations into the educational setting and eventually lower the cost per unit or make the spending worthwhile.

There is still in-depth work necessary before the space allocation model really contains all the variables of the educational system it tries to model. There is still work necessary in developing all the algorithms necessary in the model and the logical chains of the flow system. And, further simulating could be done using the output from this system for the actual architectural graphics, input into a PERT of the construction and renovation necessary, and a simulation of the construction management decision points in the development of facilities.

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